REMARKS

Claims 1-19 are pending. Claim 19 has been amended so that it depends on claims 1, 3, 8, and 13.

Claim 1 has been amended to define x as being (a) greater than 0 but less than 0.5 (i.e., $0 < x < 0.5$) or (b) greater than 0.5 but less than 1 (i.e., $0.5 < x < 1$). Support for this amendment can be found, for example, in dependent claims 3 and 13. Claim 13 defines x as being equal to y, where $0 < y < 0.5$. Claim 13, therefore, provides support for a range of values for x having an upper limit of 0.5 (i.e., $0 < x < 0.5$). Claim 3 defines x as being equal to (2-y)/3, where $0 < y < 0.5$. According to this formula, when y is less than 0.5, x is necessarily greater than 0.5. Claim 3, therefore, provides support for a range of values for x having a lower limit of 0.5 (i.e., $0.5 < x < 1$).

Claims 1, 3, 8, and 13 have been amended to recite that when M^1, M^2, M^3, M^4, or M^5 includes Ni, Co, or a combination thereof, all of the Ni, Co, and Mn included in the composition have oxidation states in air of +2, +3, and +4, respectively. Support for this amendment can be found, for example, in the specification at p. 3, line 29 to p. 4, line 2, which recites:

> [T]he particular metal elements are selected such that they exhibit appropriate oxidation states in air at the desired synthesis temperature. Conversely, the synthesis temperature may be adjusted so that a particular metal element exists in a desired oxidation state in air at that temperature.
>
> In general, eamples of suitable metal elements for inclusion in the cathode composition include Ni, co, Fe, Cu, Li, Zn, V, and combinations thereof. Particularly preferred cathode compositions are those having the following formulae:
>
> $Li[Li_{(1-2y)/3}Ni_yMn_{(2-y)/3}]O_2$;
> $Li[Li_{(1-y)/3}Co_yMn_{(2-2y)/3}]O_2$; and
> $Li[Ni_yCo_{1-2y}Mn_y]O_2$.

In the case of Ni, Co, and Mn, this passage requires oxidation states of +2, +3, and +4, respectively, as shown by working out the generalized charge balance equation for each of the three formulae. The charge balance equation is written as the sum of the oxidation states

multiplied by their stoichiometric subscripts. The total of the anions and cations must equal zero because a macroscopic material cannot have an excess negative or positive charge on it. The oxidation state of Li must be +1 and the oxidation state of O must be –2. If we start by saying that a, b, and c are the unknown oxidation states for the Ni, Co, and Mn, respectively, in the three formulae quoted above, we can analyze each equation as follows (where the number in brackets represents the oxidation state of the particular element):

(A) $Li[Li_{(1-2y)/3}Ni_yMn_{(2-y)/3}]O_2$

$1[1.0] + ((1-2y)/3)\ [1.0] + y[a] + ((2-y)/3)[c] + 2[-2] = 0$

When multiplied out, this equation reduces to:

$1 + (1/3) - y(2/3) + ya + (2/3)c - (1/3)c - 4 = 0$

Collecting the terms yields:

$y(a - (1/3)c - (2/3)) = (8/3) - (2/3)c$

Further simplying the equation yields:

$y(3a - c - 2) = 8 - 2c$

It is only when $(3a - c - 2) = 0$ and $(8 - 2c) = 0$ that this equation is satisfied for all values of y. This means that c = 4 and a = 2. Thus, charge neutrality is obtained only when Mn is in its +4 state (i.e., c = 4) and Ni is in its +2 state (i.e., a = 2).

(B) $Li[Li_{(1-y)/3}Co_yMn_{(2-2y)}]O_2$

$1[1.0] + ((1-y)/3)\ [1.0] + y[b] + ((2-2y)/3)[c] + 2[-2] = 0$

When multiplied out, this equation reduces to:

$1 + (1/3) - y(1/3) + yb + (2/3)c - y(2/3)c - 4 = 0$

Collecting the terms yields:

$y(b - (2/3)c - (1/3)) = (8/3) - (2/3)c$

Further simplying the equation yields:

$y(3b - 2c - 1) = 8 - 2c$

It is only when $(3b - 2c - 1) = 0$ and $(8 - 2c) = 0$ that this equation is satisfied for all values of y. This means that c = 4 and a = 3. Thus, charge neutrality is obtained only when Mn is in its +4 state (i.e., c = 4) and Co is in its +3 state (i.e., b = 3).

(C) $Li[Ni_yCo_{(1-2y)}Mn_y]O_2$

$1[1.0] + y[a] + (1-2y)[b] + y[c] + 2[-2] = 0$

When multiplied out, this equation reduces to:

$1 + ya + b - y2b + yc - 4 = 0$

Collecting the terms yields:

$y(a - 2b + c) = 3 - b$

It is only when $(a - 2b + c) = 0$ and $(3 - b) = 0$ that this equation is satisfied for all values of y. This means that b = 3. For (a + c), we have:

$a - 2b + c = 0$, which yields $a + c = 6$. Taking a = 2 from Formula (A) yield c = 4. Similarly, taking c = 4 from Formula (B) yield a = 2. Thus, charge neutrality is obtained only when Mn is in its +4 state (i.e., c = 4), Co is in its +3 state (i.e., b = 3), and Ni is in its +2 state.

The claims, as amended, cover cathode compositions whose formulae reflect certain criteria that the inventors have discovered are useful for maximizing cathode performance. None of the four references cited in the Office Action discloses cathode compositions that fall within the amended claims.

Claims 1-2 and 19 stand rejected under §102(b) over Nitta et al., U.S. 5,393,622 ("Nitta"). Nitta fails to describe or suggest cathode compositions falling with the formula set forth in amended claims 1-2 and 19 because the only Mn-containing embodiments described in Nitta lack Ni in its +2 oxidation state and Mn in its +4 oxidation state, as the claims require. Specifically, Nitta describes a series of compounds having the formula $Li_yNi_{1-x}Mn_xO_2$ where y = 0.1, 1.0, 1.1, 1.3, or 1.5, and x = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, or 0.7 (see Figs. 13-14 and Examples 1-2). Of these compounds, there are only six whose stoichiometry would satisfy the formula set forth in Applicants' amended claims 1-2 and 19 (i.e., $Li[M^1_{(1-x)}Mn_x]O_2$, where (a) $0 < x < 0.5$ or (b) $0.5 < x < 1$:

(a) $LiNi_{0.9}Mn_{0.1}O_2$;
(b) $LiNi_{0.8}Mn_{0.2}O_2$;
(c) $LiNi_{0.7}Mn_{0.3}O_2$;
(d) $LiNi_{0.6}Mn_{0.4}O_2$;
(e) $LiNi_{0.4}Mn_{0.6}O_2$;
(f) $LiNi_{0.3}Mn_{0.7}O_2$.

However, none of these compounds includes all of the Ni in its +2 oxidation and all of the Mn in its +4 oxidation state, as further required by Applicants' claims, because none of these compounds would achieve charge neutrality with these oxidation states, as the following calculations demonstrate:

(a) Lithium = 1.0 (+1) = 1.0;
Nickel = 0.9 (+2) = 1.8;
Manganese = 0.1 (+4) = 0.4;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 1.8 + 0.4 – 4.0 = -0.8.

(b) Lithium = 1.0 (+1) = 1.0;

Nickel = 0.8 (+2) = 1.6;

Manganese = 0.2 (+4) = 0.8;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 1.6 + 0.8 – 4.0 = -0.6.

(c) Lithium = 1.0 (+1) = 1.0;

Nickel = 0.7 (+2) = 1.4;

Manganese = 0.3 (+4) = 1.2;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 1.4 + 1.2 – 4.0 = -0.4.

(d) Lithium = 1.0 (+1) = 1.0;

Nickel = 0.6 (+2) = 1.2;

Manganese = 0.4 (+4) = 1.6;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 1.2 + 1.6 – 4.0 = -0.2.

(e) Lithium = 1.0 (+1) = 1.0;

Nickel = 0.4 (+2) = 0.8;

Manganese = 0.6 (+4) = 2.4;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 0.8 + 2.4 – 4.0 = 0.2.

(f) Lithium = 1.0 (+1) = 1.0;

Nickel = 0.3 (+2) = 0.6;

Manganese = 0.7 (+4) = 2.8;

Oxygen = 2.0 (-2) = -4.0;

1.0 + 0.6 + 2.8 – 4.0 = 0.4.

Nitta, therefore, fails to describe each element of claims 1-2 and 19. Accordingly, Nitta does not anticipate the claims and the rejection should be withdrawn.

Claims 1-7 and 19 stand rejected under §102(e) over Yanai et al., U.S. 6,368,749 ("Yanai"). Yanai describes cathode compositions that include a combination of a lithium-containing metal oxide and an aluminum sulfate. None of these compositions falls within claims 1-7 and 19 of the present application because the presence of the aluminum sulfate means that these compositions are not single phase compositions, as the claims require.

Yanai does describe, as comparative examples, three compositions that lack the aluminum sulfate but include a lithium metal oxide having Mn in combination with Ni and/or Co. These compositions are set forth in Table 2 of Yanai and have the following compositions:

(a) $LiNi_{0.5}Mn_{0.5}O_2$;

(b) $LiCo_{0.5}Mn_{0.5}O_2$;

(c) $LiNi_{0.4}Co_{0.1}Mn_{0.5}O_2$.

None of these compositions, however, meets the requirements of claims 1-7 and 19 because each contains 0.5 moles of Mn. The claims, in contrast, require the amount of Mn to be either <u>greater than</u> 0.5 (i.e., $0.5 < x < 1$) or <u>less than</u> 0.5 (i.e., $0 < x < 0.5$), but never <u>equal to</u> 0.5. Yanai, therefore, fails to describe each element of claims 1-7 and 19. Accordingly, Yanai does not anticipate the claims and the rejection should be withdrawn.

Claims 1-2, 8-12, and 19 stand rejected under §102(e) over Paulsen et al., U.S. Pub. 2003/0022063 ("Paulsen"). Paulsen proposes cathode compositions that fall within one of two broad generic formulae: $Li[Li_xCo_y(Mn_zNi_{1-z})_{1-x-y}]O_2$ or $Li[Li_xCo_y(Mn_2Ni_{1-z})_{1-x-y}]O_2$, where x = 0 - 0.16; y = 0.1 - 0.3; and z = 0.4 – 0.65. While it might theoretically be possible to selected appropriate values of a, b, and c such that Ni, Co, and Mn have oxidation states of +2, +3, and

+4, respectively, in air, Paulsen provides no guidance whatsoever as to how to select the particular combinations necessary in order to achieve this result from among the multitude of possible combinations. Moreover, the only working examples that Paulsen provides lack Ni, Co, and Mn in these oxidation states (where the charge figure was calculated as described above in the case of Nitta):

Example 2A: $Li[Li_{0.095}Co_{0.046}Ni_{0.434}Mn_{0.424}]O_2$
Charge = -0.200

Example 2B: $Li[Li_{0.134}Co_{0.044}Ni_{0.416}Mn_{0.406}]O_2$
Charge = -0.278

Example 2C: $Li[Li_{0.083}Co_{0.093}Ni_{0.413}Mn_{0.412}]O_2$
Charge = -0.167

Example 2D: $Li[Li_{0.123}Co_{0.089}Ni_{0.395}Mn_{0.394}]O_2$
Charge = -0.247

Example 2E: $Li[Li_{0.064}Co_{0.158}Ni_{0.388}Mn_{0.389}]O_2$
Charge = -0.127

Example 2F: $Li[Li_{0.106}Co_{0.151}Ni_{0.371}Mn_{0.372}]O_2$
Charge = -0.211

Example 4: $Li[Li_{0.048}Co_{0.152}Ni_{0.39}Mn_{0.41}]O_2$
Charge = -0.076

Example 5A: $Li[Li_{0.11}Co_{0.148}Ni_{0.371}Mn_{0.371}]O_2$

Charge = -0.220

Example 5B: $Li[Li_{0.11}Co_{0.142}Ni_{0.365}Mn_{0.383}]O_2$

Charge = -0.202

Example 5C: $Li[Li_{0.09}Co_{0.146}Ni_{0.373}Mn_{0.391}]O_2$

Charge = -0.162

Example 6: $Li[Li_{0.05}Co_{0.14}Ni_{0.37}Mn_{0.37}Al_{0.07}]O_2$

Charge = -0.1 (assuming a +3 oxidation state for Al).

As the calculations demonstrate, charge neutrality cannot be obtained if all of the Ni, Co, and Mn are in their +2, +3, and +4 oxidation states, respectively. Paulsen, therefore, fails to describe cathode compositions that meet the requirements of claims 1-2, 8-12, and 19. Accordingly, Paulsen does not anticipate the claims, and the rejection should be withdrawn.

Claims 1-2 and 13-19 stand rejected under §102(e) over Sunagawa et al., U.S. 6,333,128 ("Sunagawa"). Sunagawa describes compositions having the formula $Li_aCo_bM_cNi_{1-b-c}O_2$, where M may be Mn. As in the case of Paulsen, while it might theoretically be possible to selected appropriate values of a, b, and c such that Ni, Co, and Mn have oxidation states of +2, +3, and +4, respectively, in air, Sunagawa provides no guidance whatsoever as to how to select the particular combinations necessary in order to achieve this result from among the multitude of possible combinations. Moreover, the only Mn-containing examples that Sunagawa provides lack Ni, Co, and Mn in these oxidation states (where the charge figure was calculated as described above in the case of Nitta):

Example A1: $Li[Co_{0.01}Mn_{0.01}Ni_{0.98}]O_2$

Charge = -0.97.

Example A2: $Li[Co_{0.01}Mn_{0.20}Ni_{0.79}]O_2$

Charge = -0.59.

Example A3: $Li[Co_{0.01}Mn_{0.40}Ni_{0.59}]O_2$

Charge = -0.19.

Example A4: $Li[Co_{0.1}Mn_{0.40}Ni_{0.50}]O_2$

Charge = -0.10.

Example A5: $Li[Co_{0.20}Mn_{0.01}Ni_{0.79}]O_2$

Charge = -0.78.

Example A6: $Li[Co_{0.20}Mn_{0.20}Ni_{0.60}]O_2$

Charge = -0.4.

Example A7: $Li[Co_{0.20}Mn_{0.30}Ni_{0.50}]O_2$

Charge = -0.2.

Example A8: $Li[Co_{0.40}Mn_{0.01}Ni_{0.59}]O_2$

Charge = -0.58.

Example A9: $Li[Co_{0.40}Mn_{0.10}Ni_{0.50}]O_2$

Charge = -0.40.

Example B1: $Li[Co_{0.45}Mn_{0.05}Ni_{0.50}]O_2$

Charge = -0.45.

Example B2: $Li[Co_{0.05}Mn_{0.45}Ni_{0.50}]O_2$

Charge = -0.05.

Example B3: $Li[Co_{0.15}Mn_{0.40}Ni_{0.45}]O_2$

Charge = -0.05.

Example B4: $Li[Co_{0.40}Mn_{0.15}Ni_{0.45}]O_2$

Charge = -0.30.

Example B5: $Li[Co_{0.00}Mn_{0.10}Ni_{0.90}]O_2$

Charge = -0.80.

Example 4: $Li[Co_{0.30}Mn_{0.10}Ni_{0.60}]O_2$

Charge = -0.50.

As the calculations demonstrate, charge neutrality cannot be obtained if all of the Ni, Co, and Mn are in their +2, +3, and +4 oxidation states, respectively. Sunagawa, therefore, fails to describe cathode compositions that meet the requirements of claims 1-2 and 13-19. Accordingly, Sunagawa does not anticipate the claims, and the rejection should be withdrawn.

Please apply any charges or credits to deposit account 06-1050.

Respectfully submitted,

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